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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

APPLICANT(S): Richard Anthony Cox et al.

SERIAL NO.: 09/774,157

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TITLE: AIR CONTENT DETERMINATION

ART UNIT: Unassigned

EXAMINER: Unassigned

DOCKET: 7000/1

Assistant Commissioner for Patents
Washington, DC 20231

LETTER REGARDING SUBMISSION OF PRIORITY DOCUMENT

The above referenced application claims priority from Great Britain patent application GB 0002081.8, filed January 28, 2000. Applicant submits herewith a certified copy of the priority application.

Respectfully submitted,

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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1.	Your reference	SAH01162GB
2.	Patent application number *(The Patent Office will fill in this part)*	0002081.8 — 28 JAN 2000
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Cambridge University Technical Services Ltd The Old Schools Trinity Lane Cambridge CB2 1TS United Kingdom
	Patents ADP number *(if you know it)*	6956809004
	If the applicant is a corporate body, give the country/state of its incorporation	
4.	Title of the invention	Atmospheric Content Detection
5.	Name of your agent *(if you have one)*	Gill Jennings & Every
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Broadgate House 7 Eldon Street London EC2M 7LH
	Patents ADP number *(if you know it)*	745002
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country / Priority application number *(if you know it)* / Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application / Date of filing *(day / month / year)*
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

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Continuation sheets of this form	
Description	7
Claim *(s)*	0
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Drawing *(s)*	6 + 6

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Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	NO

11. For the applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date
28 January 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

HALEY Stephen
020 7377 1377

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ATMOSPHERIC CONTENT DETECTION

This invention relates to devices for the detection of atmospheric components.

In recent years, with increased concern in relation to environmental issues, more and more emphasis has been placed on the ability to provide accurate and cost effective measurement devices and methods for the detection of particular contaminants and general components in the atmosphere.

One way of detecting atmospheric composition up to high altitudes is to attach sensors to a helium filled weather balloon and to launch the balloon into the atmosphere. The sensor then transmits data, usually via a radio link, as the balloon passes up through the atmosphere. The fact that the sensor is attached to a balloon places severe restrictions, in terms of weight and cost on the sensor design. The cost aspect can be particularly critical, because generally such sensors have to be treated as disposable, given that they may be difficult to locate once they fall back to the ground. All of this can make it extremely difficult to produce a sensor which provides appropriately accurate readings that are continuous throughout the ascent of the balloon and which is capable of resisting the effects of high altitude and low temperature, where contaminants such as rain ice can affect sensor output.

Current systems usually use a pump to draw air into a sensing arrangement. The pumps are expensive, relatively heavy and require considerable power to operate, increasing overall device weight.

Furthermore, with such sensors it can often be difficult to provide accurate readings because it is difficult to determine exactly the rate at which atmospheric air is flowing over the sensor.

A further problem associated with sensors, both those which are ground based and which are drawn up through the

atmosphere, is that it is often difficult for them to detect reliably and accurately certain contaminants for components of the atmosphere that are of particular interest. Particularly, there are certain contaminants, such as ozone, NO and NO_2, for which there is a keen interest in obtaining accurate readings, but for which the necessary sensing circuitry is expensive and not particularly accurate.

The present invention seeks to provide sensing devices which overcome some of the above problems.

According to the present invention there is provided a sensor for detecting components in atmospheric air as the sensor is drawn up through the atmosphere, the sensor comprising:

a sensor element;

shielding means for shielding the sensor element from direct contact with air flow as the sensor is drawn through the atmosphere; and

means for diverting air through the shielding means and over the sensor element as the sensor passes through the atmosphere.

The means for diverting air may comprise a hollow cylinder comprising a flow restricting member for diverting air that flows through the hollow cylinder in use into the shielding means. Alternatively, the diverting means may comprise a Venturi flow generating cylinder, which generates a pressure differential across the shielding means and draws air through the shielding means and into the cylinder in use.

According to the present invention there is also provided a sensor comprising:

a sensor element;

means for determining the temperature of the sensor element; means for providing heat energy to the sensor element; and means for calculating the air flow across the sensor element by employing the output of the sensor element temperature detecting means and the heat energy

input detecting means and providing an output related thereto.

This second embodiment of the invention may be combined with the first embodiment in order to determine the flow of air directed into the shielding means.

Examples of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-sectional diagram of a first example of the present invention;

Figure 2 is a schematic sectional view of a second example of the present invention;

Figure 3 is a schematic cross-sectional view of a third example of the present invention;

Figures 4a and 4b are graphs showing a time dependence of concentrations of NO, NO_2 and O_3 during photolysis in air for differing concentrations of a NO_2;

Figures 5a and 5b show the effects of NO_2 concentration on O_3 production after photolysis; and

Figure 5 is a schematic side view of a sensor according to the present invention.

Referring to figure 1, a sensor 1 according to the invention is configured to be attached to a weather balloon (not shown) so that, in use, it can be drawn up through the atmosphere by the weather balloon. The arrow in the diagram indicates the direction of air flow through the sensor 1 when in use. The sensor 1 has a cylindrical member 2 which has a shape such that its diameter in its central portion is less than that at either of its ends. Such a configuration generates, in use, a regions of low pressure in the central narrow region of the cylindrical member 2. In the central region is positioned a sensor element 3 and a shield member 4 which protects the sensor element 3 from damage due to hailstones, heavy rain, etc during use of the sensor 1. The shield 4 is arranged such

that it connects to the central region of the cylindrical member 2. In use the low pressure region generated in the cylindrical member 2 draws air into the shield 4 and over the sensor element 3. In this example the sensor element 3 is configured to detect ozone but it is possible to detect other atmospheric matter also.

Figure 2 shows second example, in which components corresponding to those in figure 1 are numbered identically. In this example a constricting member is provided at what is, in use, the lower end of cylindrical member 2. The constriction has a narrow opening 8 to allow particles such as rain and ice to fall out of the cylindrical member 2, but which is narrow enough to direct air through the shield 4 and over sensor 3.

Figure 3 shows a detail of a sensor element 3 in a shield 4. In this example the air flow over the sensor element 3 may be generated by a device shown in figures 1 or 2 or by more conventional positioning of the sensor element within a known sensor device. It does, however, have particular benefits in the configuration shown in figures 1 and 2.

In this example the sensor element 3 is supported by electrical connecting wire 6 which connects to a sensor driving and monitoring device 7. The wires provide electrical energy to a heating element (not shown) on the sensor 3 or adjacent to the sensor element 3 itself, causing the sensor element 3 to be heated. Airflow over the sensor element 3 when the sensor 1 is in use cools the sensor element 3 and the actual temperature of the sensor element 3 can be determined by a temperature sensor (not shown). The output of the temperature sensor, together with the electrical energy input to heat the sensor element 3 is determined by the sensor element driving means 7 and used to calculate the air flow over the sensor element 3.

This air flow data is useful in determining operating parameters and to increase the accuracy of the sensor 1.

Referring to figure 6, a sensor 10 according to a further example of the present invention has an inlet 11 into which atmospheric air is drawn in use. The inlet 11 is connected to a chamber 12 which is incased in internally reflecting material 13, such as metal foils. Through the sensor of the chamber 12 there is positioned a UV light source 14, which maybe a standard UV lamp or other lower power UV light source. The chamber 12 is also connected to a sensor element 15 which is connected via wires 18 to electrical processing circuitry. Furthermore, the chamber 12 is connected to a pump (not shown) by an outlet 16 so that, in use, the pump can be employed to draw atmospheric air in from the inlet, through the chamber 12 and pass the sensor 15. A light trap 17 is provided to prevent light from the UV light source 40 reaching the sensor element 15 and generate spurious readings.

In use the sensor 10 is operated to draw a sample of air through the chamber 12 and past the sensor 15 and the level of ozone present in the air is detected. The UV light source 14 is then turned on.

The presence of a UV light source in the chamber 12 alters the equilibrium point of the equation:

$$NO_2 + O_2 \rightarrow NO + O_3$$

urging it to the right and increasing the amount of ozone in the chamber 12 and hence as detected in the sensor 15. Provided that the chamber 12 is sufficiently long and the amount of UV light produced by the source 14 is sufficiently large, together with appropriate control of airflow, the ozone level detected by the sensor will increase to a peak related to the concentration of NO_2

present. Of course, operation of the sensor 10 in this manner is dependent upon the amount of ozone being drawn in through inlet 11 being constant throughout the measuring process. In practice this may not be the case, and it may be preferable to provide a further ozone sensor (not shown) at the inlet 11, so that a difference between inlet ozone and outlet ozone can be determined and this difference employed to measure the NO_2 present.

Figures 4a and 4b show the level of ozone and NO_2 present and detected by a system according to the present invention. In figure 4b ozone has been removed from the sample that is drawn into inlet 11, and it can be seen that the level at which the ozone settles to a steady state is proportional to the level of NO_2 present in the sample therein.

The time taken to reach the equilibrium state of the equation listed above is also affected by the concentration of NO in the sampled air. For this reason, by providing a sensor 10 with appropriate sensitivity, it is also possible to determine the concentration of NO in the air drawn in through inlet 11 during provision of UV light by UV light source 14. It has been determined that the rate at which the level of ozone reaches a steady state during operation of the sensor is invective of the level of NO present. By determining this rate the sensor can therefore also provide an indication of the level of NO present, given that the level of NO_2 has been determined.

It will be appreciated that it may be possible to pre-treat the samples provided to the sensor 10 in situations where it is not necessary to determine the levels of ozone, NO, or NO_2, the pre-treatment involving the removal of one or more of these gases. This will simplify the processing of sensor signal output to ensure a higher and faster

accuracy in the measurement of the specific gas of interest.

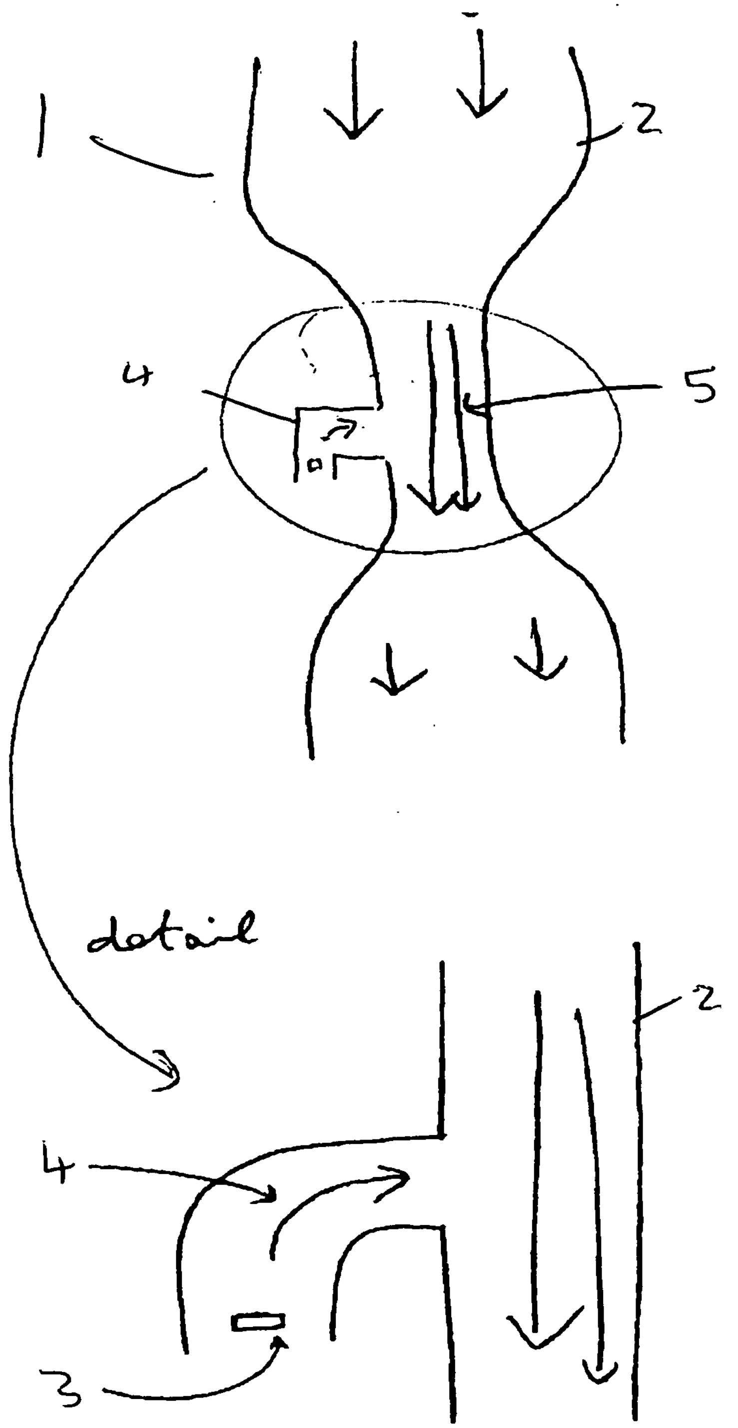


Fig 1

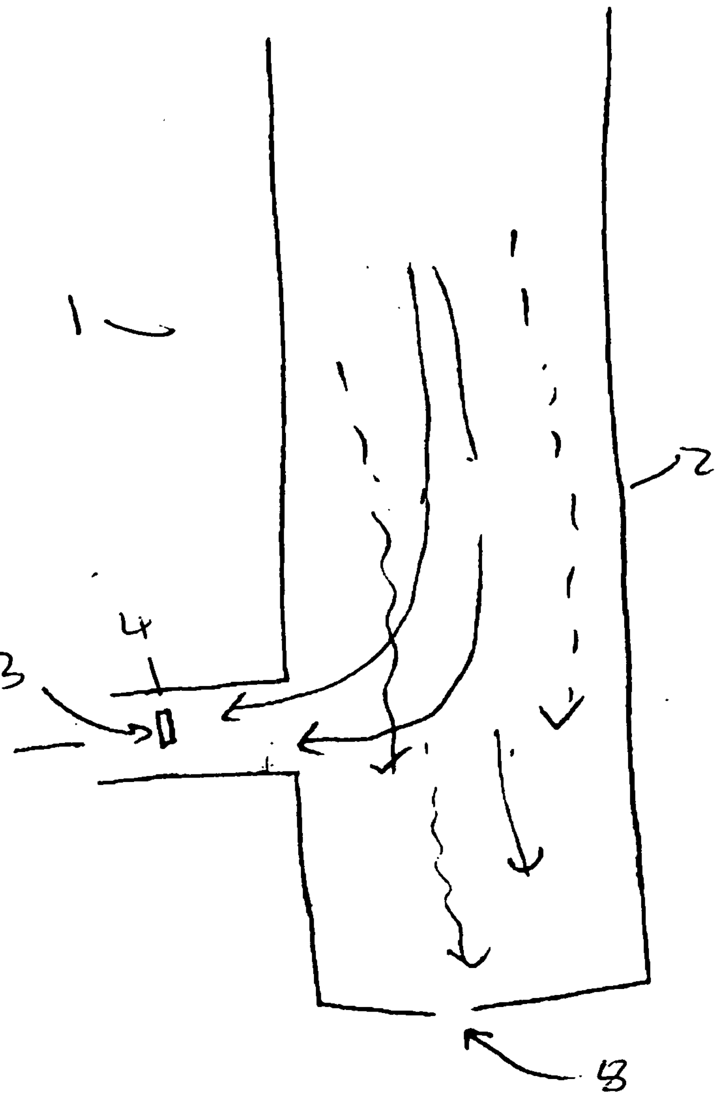


Fig 2

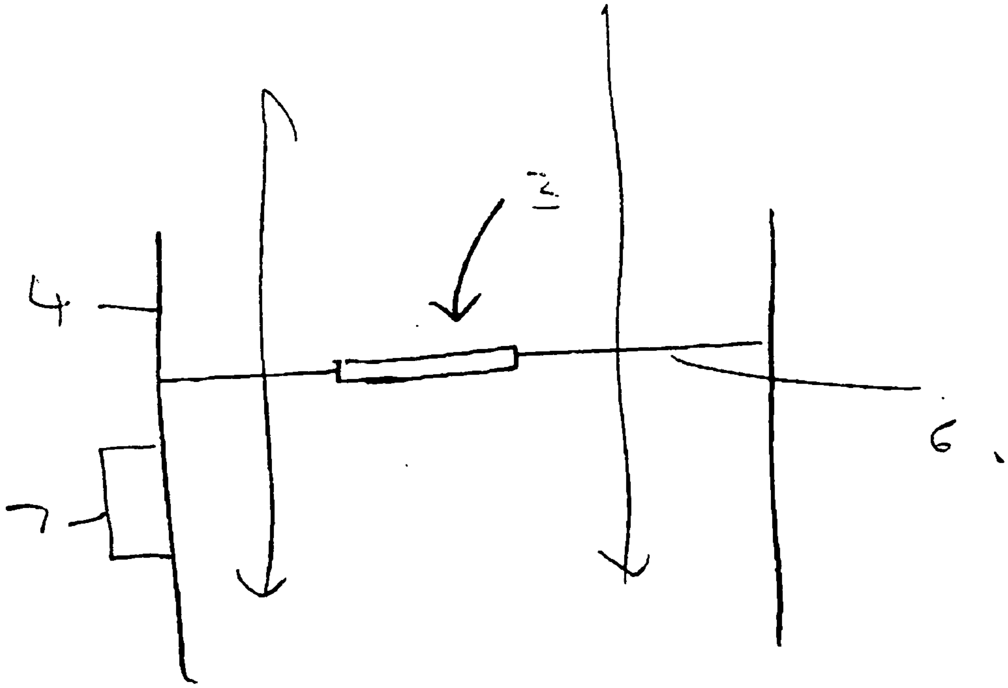
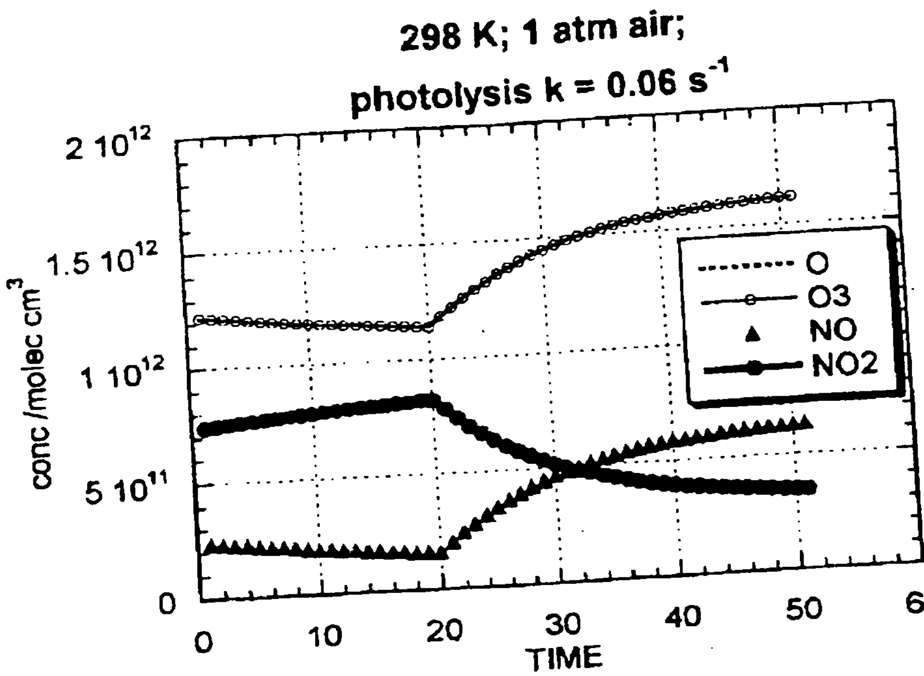
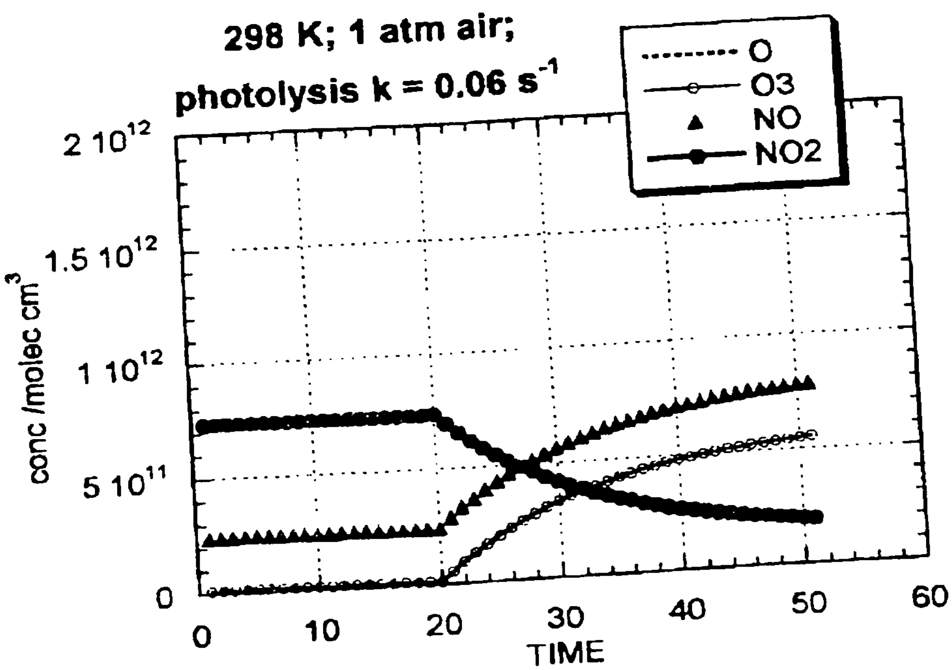


Fig 3



298 K; 1 atm air;
photolysis k = 0.06 s-1
conc /molec cm3
2 10^12
1.5 10^12
1 10^12
5 10^11
0
0
10
20
30
40
50
60
TIME
O
O3
NO
NO2

Fig. 4A



298 K; 1 atm air;
photolysis k = 0.06 s-1
conc /molec cm3
2 10^12
1.5 10^12
1 10^12
5 10^11
0
0
10
20
30
40
50
60
TIME
O
O3
NO
NO2

Fig. 4B

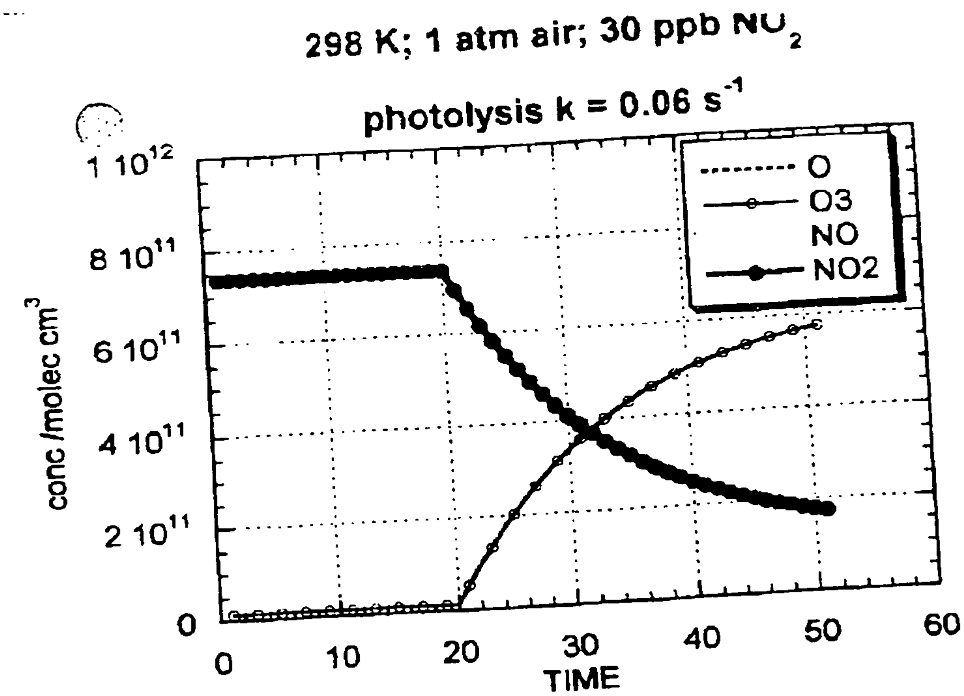

298 K; 1 atm air; 30 ppb NO2
photolysis k = 0.06 s-1
conc /molec cm3
TIME
O
O3
NO
NO2

Fig 5A

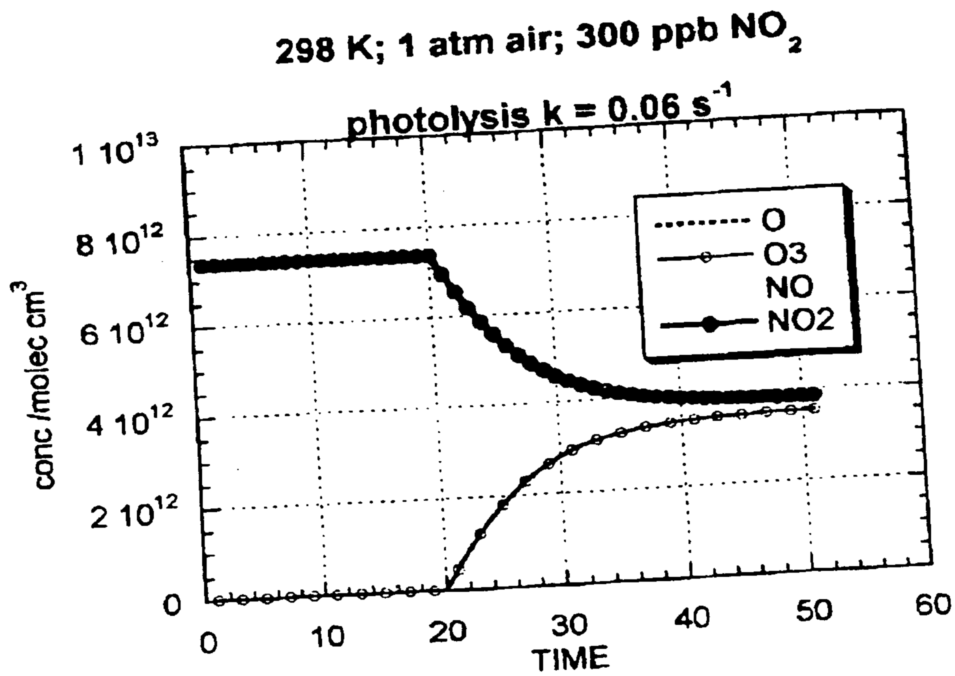

298 K; 1 atm air; 300 ppb NO2
photolysis k = 0.06 s-1
conc /molec cm3
TIME
O
O3
NO
NO2

Fig 5B

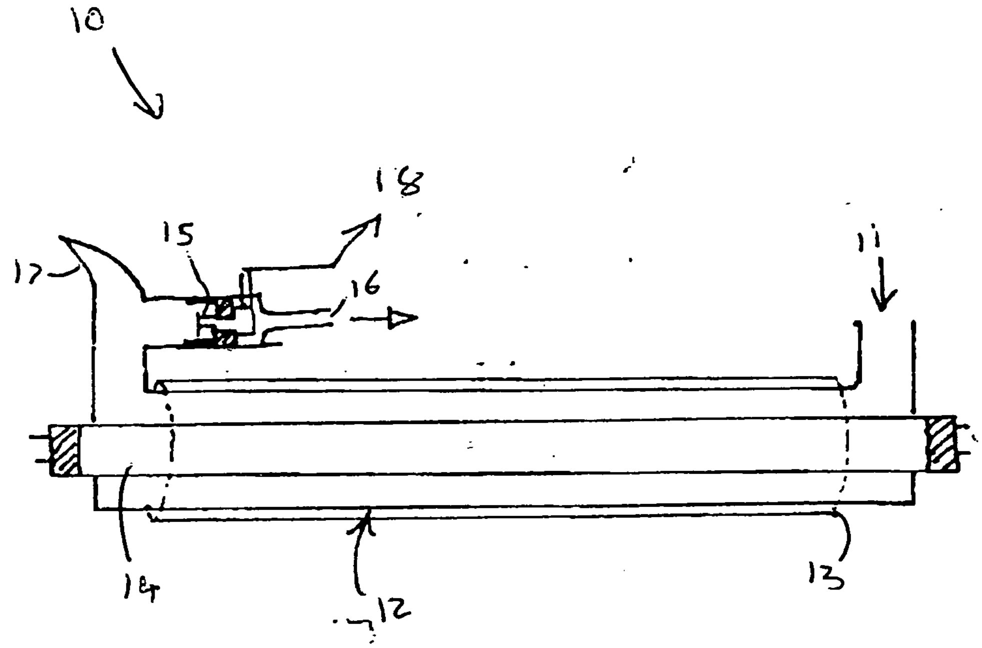


Fig 6